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GB 2215505 A

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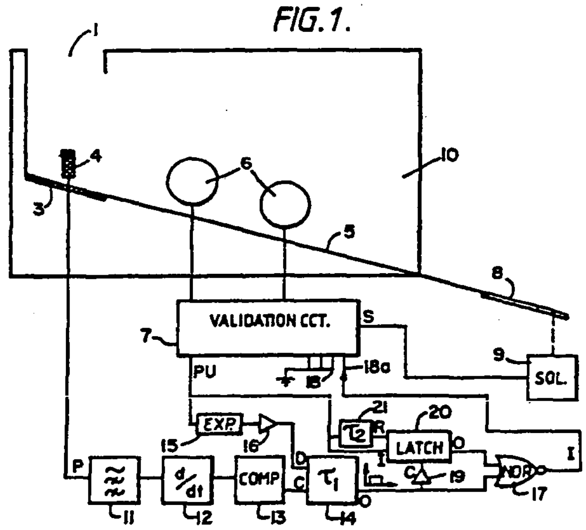
(54) Coin validator with impact sensor

(57) A coin is inserted in a coin entry 1 and caused to fall under gravity on to an energy-absorbing element 3. The impact of the coin on the element is sensed by a piezoelectric sensor 4 and coins are discriminated between on the basis of whether the gradient of at least a part of the signal from sensor 4 meets an acceptability criterion. Preferably the output of the sensor is fed through a high-pass filter 11 to a differentiating circuit 12, the differentiated output being compared with a predetermined threshold value and, if greater, an output signal being generated. This signal, optionally together with a coin presence signal from coils 6, is supplied to circuitry 15, 16, 17, 19, 20, 21 for causing an output inhibit signal I to drop to a low level. The signal I is applied to an inhibit terminal 18a associated with a validation circuit 7 for causing, in the case of a coin deemed to be acceptable, an acceptance gate 8 to be opened by a solenoid 9. The inductive coils 6 also serve to determine whether a coin being tested is of a desired denomination. The acceptability signal is generated only if the coin passes through the region of the coils within a predetermined interval and if there is not already a coin in the region when a coin hits the element 3. Lid 10 may be pivoted open to release jammed coins.

FIG.1.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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FIG.1.

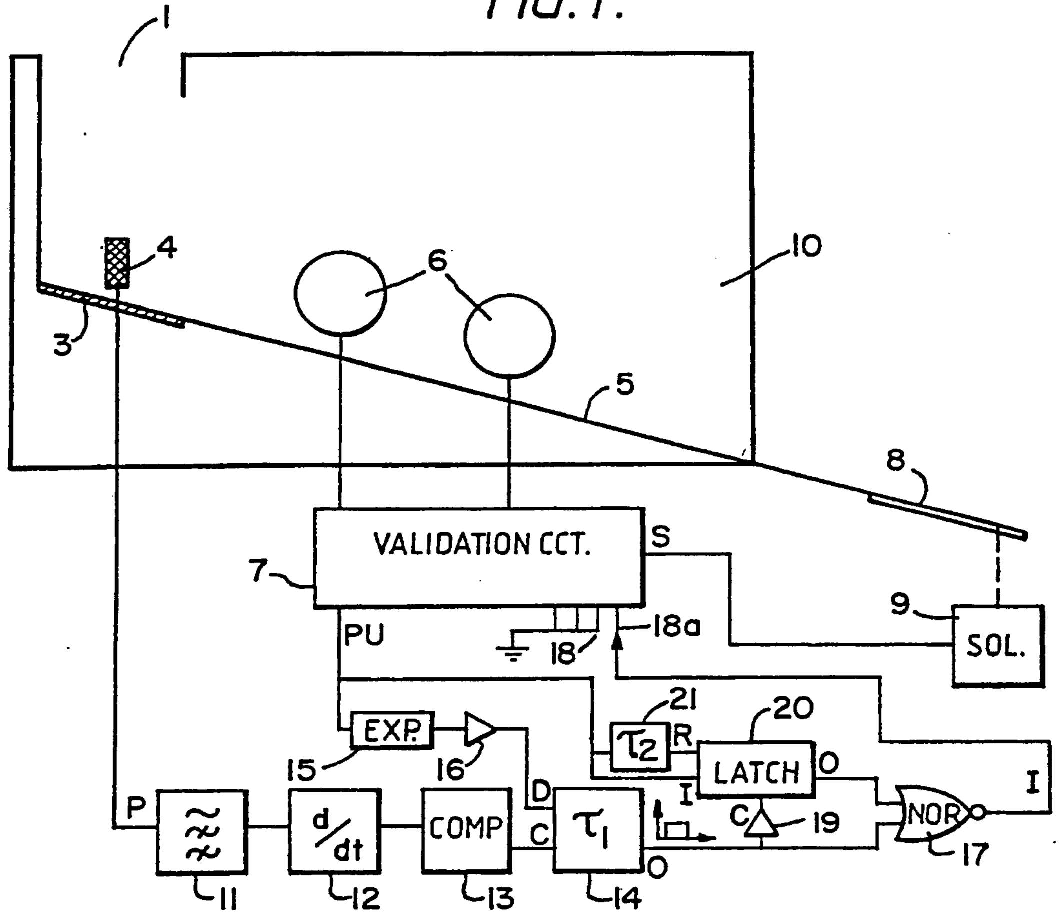
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FIG.2.

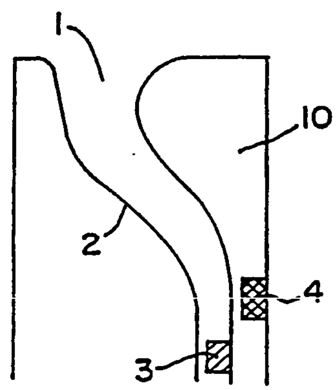
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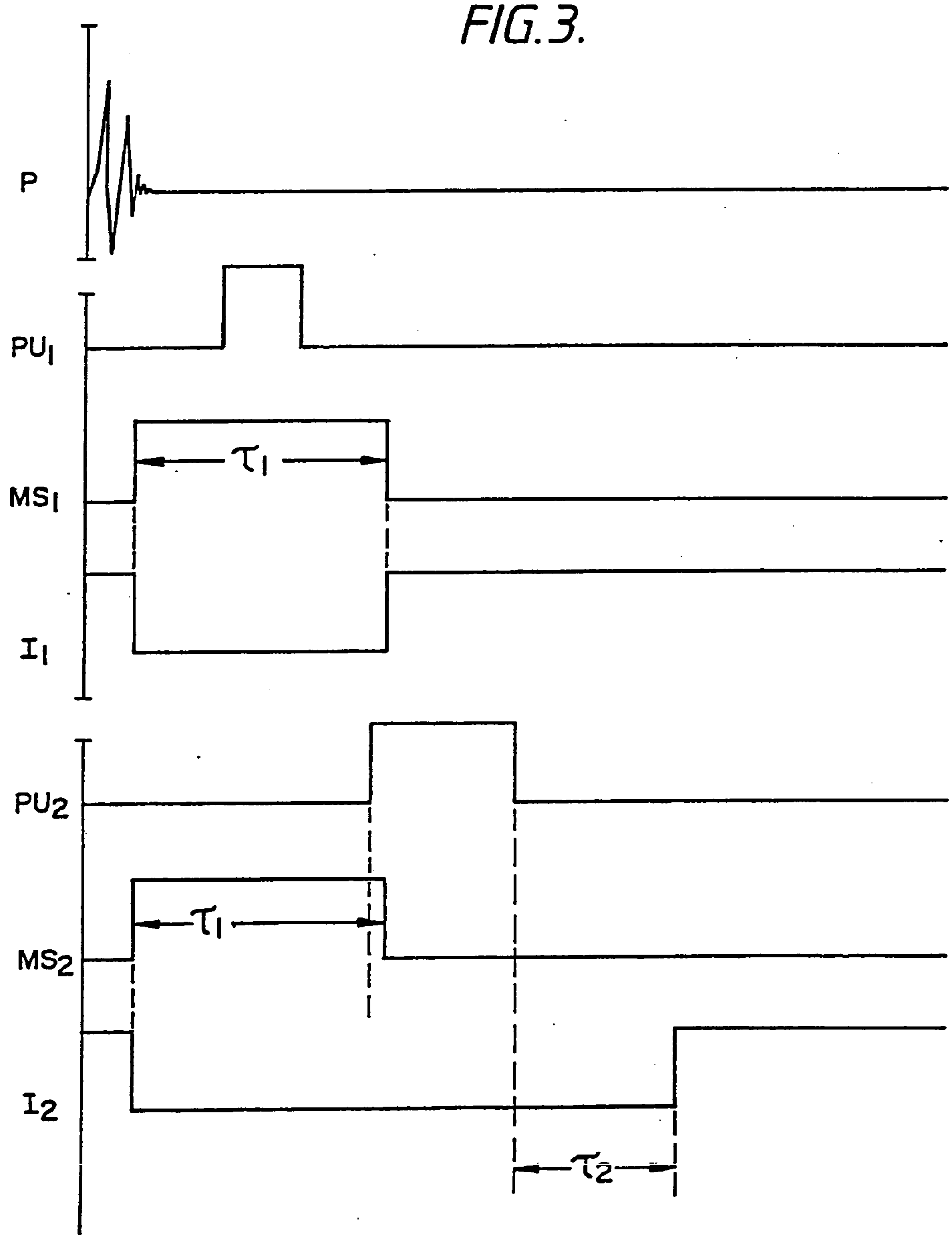
FIG. 3.



METHOD AND APPARATUS FOR COIN VALIDATION

The present invention relates generally to coin validation for distinguishing between acceptable and non-acceptable coins. More particularly, the present invention relates to coin validation employing an impact sensor such as a piezoelectric element.

The term "coin" as used herein is intended to mean either a coin or a token. A coin is considered to be acceptable if it is genuine and of a desired denomination. Correspondingly, a coin is considered non-acceptable if it is either counterfeit or genuine but of a non-desired denomination.

Validators employing solely electromagnetic sensors such as inductive coils are well known, but discrimination is based on coin dimensions and/or the electromagnetic properties of the coin material. Furthermore, validators incorporating optical sensors discriminate on the basis of coin dimensions and/or the optical properties of coins. It has been found that certain types of counterfeit coins such as lead discs or discs made from a lead alloy such as "Printer's Metal" are able to 'fool' such validators, i.e. they are taken to be acceptable, since their dimensional and/or electromagnetic and/or optical characteristics are too similar to acceptable coins to

permit effective discrimination. In addition, lead and lead alloys are commonly used to produce such counterfeit coins on account of their malleability. Furthermore, genuine coins of low denominations having tape wound around their circumference cannot always effectively be distinguished from genuine coins of higher denomination in such validators.

Coin validators incorporating piezoelectric elements for sensing the impact of a coin falling on to part of a coin track (e.g. an energy-absorbing element) are known from e.g. International Patent Application No. 83/00400 (Meyer) and published British Patent Application No. GB-A-2 173 624 (Quonaar).

Such validators are described as being adapted to discriminate between acceptable and non-acceptable coins on the basis of the mechanical properties of the coin material, and it is said that this criterion is useful for discriminating between acceptable coins and some types of counterfeit coins.

In the Meyer system the amplitude of the output of the piezoelectric sensor is compared with a predetermined threshold amplitude value to determine whether or not a coin meets an acceptability criterion.

In the Quonaar system the mass of a coin is said to be measured by sensing the output of the

piezoelectric element and supplying this output to an integrator, the resultant integrated signal being indicative of the mass of the coin. The integrated signal is compared with a predetermined threshold value to determine whether or not the coin meets an acceptability criterion.

However, the above systems incorporating piezoelectric sensors require coins to be inserted from a constant height and/or coins to impact the coin track at a predetermined velocity, since variations in such height or velocity affect the ability of the validators to discriminate effectively between acceptable and non-acceptable coins.

GB 1 293 975 (Ticket Equipment Ltd.) describes a coin handling mechanism provided with a hopper having a large mouth for the simultaneous insertion of a number of coins. A vibration sensor such as a piezoelectric device is used to sense the impact of a coin to initiate a vending operation. The sensor output is passed through a high-pass filter to prevent erroneous operation resulting from spurious signals generated outside the machine or from impacts caused by unwanted objects other than coins, which can presumably enter the apparatus due to the large size of the hopper mouth. There is no suggestion, however, of using the vibration sensor to discriminate between

genuine and counterfeit coins.

According to a first aspect of the present invention there is provided a coin validator comprising a coin entry, an impact surface positioned such that a coin having entered said entry will impact thereon, a sensor for detecting the impact of the coin on said surface so as to generate an output signal in response thereto and means capable of discriminating between impacts caused by genuine and counterfeit coins on the basis of whether or not the gradient of at least a part of said output signal meets a coin acceptability criterion.

Such an arrangement has the advantage of being significantly less sensitive to the height from which a coin is caused to fall on to the impact surface or the velocity with which the coin impacts the surface, and has been found to result in very good discrimination between genuine coins and counterfeits of the type mentioned above.

The validator preferably further comprises means connected to said discriminating means for generating an acceptability signal in response to the determination.

The validator preferably further comprises means for sensing the presence of a coin within a region (referred to herein as a measurement region or field

because further measurements are preferably carried out therein) through which the coin is caused to pass after impacting the impact surface, so as to generate a coin presence signal in response thereto. There may be means for inhibiting the acceptability signal if an output signal and a coin presence signal occur at the same time. Means may be provided for inhibiting the acceptability signal if the output signal occurs within a predetermined interval of time following the occurrence of the coin presence signal. Such features avoid erroneous acceptance of a counterfeit coin caused by a genuine coin hitting the impact surface while the counterfeit coin is still in or near the measurement region.

Preferably, the arrangement is such that a genuine coin will be accepted only if it is detected in the measurement region within a first predetermined period of the impact being sensed. This period may be automatically extended for slow moving coins whose presence in the measurement region is sensed at the end of the first predetermined period. The period may for example last until the end of a second predetermined period following departure of the coin from the measurement region.

The validator may further comprise means for performing an additional measurement on a coin having

entered the entry, such as, for example, an electromagnetic and/or an optical measurement, wherein the acceptability signal generating means is adapted to generate the acceptability signal in response to the additional measurement in combination with the output signal generated by the impact. Means may further be provided for generating a signal indicative of the denomination of the coin on the basis of the additional measurement.

The coin acceptability criterion is preferably specific to coins of a single denomination.

The discriminating means may be adapted for comparing the gradient with a predetermined value.

The discriminating means may comprise means for differentiating at least a part of the output signal and means for detecting whether the resultant differentiated signal meets a predetermined criterion.

The discriminating means preferably comprises a high-pass filter which may advantageously be connected between the output of the sensor and the differentiating means. The high-pass filter preferably has a break point between 10 and 20 kHz. The exact desired value depends on the structure of the validator, but a value of 15 kHz is especially preferred. The differentiating means is preferably so structured as to provide unity gain at the high-pass

filter break point frequency, thereby enhancing the cut-off of signals below the break point frequency. Thus, that part of the output signal passed by the high-pass filter has its gradient checked against the coin acceptability criterion. The provision of such a filter has been found to enhance discrimination.

The impact surface and the sensor are advantageously both carried by an integrally formed structure of the validator. Preferably this is the lid of the validator, so that external impacts applied to the validator are less likely to cause the sensor to generate an erroneous output signal.

The impact surface may comprise a surface of the sensor, although in the preferred embodiment it is instead a surface of a separate energy-absorbing element.

The sensor is preferably a piezoelectric sensor which may be formed from a ceramic material.

According to a second aspect of the present invention there is provided a method of validating coins comprising sensing the impact of a coin hitting an impact surface, generating an output signal in response thereto and discriminating between impacts caused by genuine and counterfeit coins on the basis of whether or not the gradient of at least a part of said output signal meets a coin acceptability criterion.

An embodiment of the invention will now be described with reference to the accompanying drawings in which:

Figure 1 shows in schematic form a coin validator incorporating a piezoelectric sensor in accordance with the present invention;

Figure 2 shows in cross section the coin entry of the coin validator of Figure 1; and

Figure 3 is a signal waveform diagram illustrating the operation of the coin validator of Figure 1.

With reference to Figures 1 and 2, the coin validator comprises a coin entry 1 into which a coin may be inserted. Just below the point of entry the coin track is provided with a curved portion 2 (see Figure 2) having a curve within a plane perpendicular to the plane of a falling coin. Such a curved portion is provided for the purpose of reducing the speed of a coin which is forcibly pushed into the coin entry. The desirability of this will become apparent from the following. At the bottom of this part of the coin track there is provided a ceramic energy-absorbing element 3. The material of this element is such that the momentum of the coin is substantially absorbed thereby so as to prevent the coin bouncing. The

impact of the coin on the element causes vibration not only in the element itself but in the surrounding parts of the coin validator, and this is sensed by a piezoelectric sensor 4 mounted in proximity to the energy-absorbing element 3. The element 3 and the sensor 4 are mounted on the same side of the coin track. Although, as will be explained, discrimination between acceptable and non-acceptable coins is intended not to be dependent on the magnitude of the impact of a coin on the element 3, a non-acceptable coin in this embodiment may, if it impacts the element 3 with sufficient force, cause the sensor to generate a signal which would "fool" the validator into determining the coin to be acceptable. It follows that if the part of the coin track just below the entry were in the form of a straight path, then the validator might be thus "fooled" by a non-acceptable coin being pushed forcibly into the entry so as to increase its impact on the energy-absorbing element. The provision of the curved portion serves to eliminate this possibility by reducing the velocity of the coin and hence reducing the impact on the element. After hitting the element, the coin is caused by gravity to roll down an inclined track 5 at one or both sides of which is provided induction coils, such as those shown at 6, connected to a validation circuit

7 forming part of the coin validation system.

At the bottom of the coin track 5 there is provided an acceptance gate 8 operated by a solenoid 9 which causes the coin to be directed into one of two possible exit paths in dependence on whether or not the coin is determined to be acceptable. It is the output signal P of the piezoelectric sensor 4, in combination with the output of the induction coils 6, which is used to determine whether or not a coin is acceptable.

In order to prevent a coin or similar object having a thickness greater than that of the coin track from becoming jammed therein, the coin validator is provided with a mechanism for opening up the coin track so as to release any article which has become lodged therein. This involves pivoting one side of the coin track about an axis, this side being known as the "lid" of the coin validator. Such an arrangement is well known in coin validation systems, an example of which is described in patent specification US 3,907,086. It is this lid 10 on which both the energy-absorbing element 3 and the piezoelectric sensor 4 are mounted in the present embodiment, as shown in Figure 2. Alternatively, both could be mounted to the body to which the lid is hinged. It is, however, preferable for both to be

fixed to an integrally formed structure.

The validation circuit 7 analyses the electrical output signals from the induction coils 6 and not only serves to validate a coin but also to determine its denomination, and is provided in a per se known manner with a plurality of selective inhibit terminals 18 corresponding to a respective plurality of denominations of coins which the validation circuit is adapted to validate. An example of a known coin validator provided with such selective inhibit terminals is the model MS111 obtainable from Mars Electronics International of Eskdale Road, Winnersh Triangle, Wokingham, Berkshire, RG11 5AQ, United Kingdom. An inhibit signal applied to any one of these selective inhibit terminals will prevent validation of a coin of the respective denomination. In the present embodiment all but one of the terminals 18 are permanently held at a low potential, with no external inhibit signal being supplied thereto. The remaining inhibit terminal 18a is that associated with a selected denomination which is likely to be erroneously indicated to be acceptable when a lead or lead alloy disc is inserted, and it is this inhibit terminal to which an output inhibit signal I is selectively supplied in dependence on the signals generated by piezoelectric sensor 4.

The arrangement is such that, when a coin of the selected denomination is inserted, the signal I drops to its low level so as to remove the inhibit and to allow validation to occur.

If the sensors 6 indicate the presence of a coin which passes the electromagnetic tests performed by the validator circuit 7 for the denomination associated with the selected inhibit terminal 18a, the validation circuit 7 will generate a validation signal S. The validation signal S operates the solenoid 9 for opening the acceptance gate 8. The signal S is prevented from appearing if the signal I has not already adopted a low level in response to the output of the piezoelectric sensor 4.

The validation circuit 7 connected to the induction coils 6 is in the form of an integrated circuit chip and is well known in the field of coin validation, and therefore further description thereof is omitted. An example of such a validation circuit is disclosed in published British patent application GB-A-2,093,620. The circuitry external to the validation circuit 7 can be provided in an add-on manner to such an integrated circuit chip such that complete re-design of the integrated circuit chip itself is unnecessary. Of course, such re-design would be possible, if desired.

The piezoelectric sensor 4 produces an electrical output (represented schematically as P in Figure 3) in dependence on the impact of the coin on the energy-absorbing element 3. This electrical output is supplied to a high-pass filter 11 which serves to block low-frequency components of the sensor output signal. The high-pass filter has a break frequency of about 15 kHz, i.e. it provides unity gain for frequencies in excess of this value, with gain fall-off of about 3dB per octave for frequencies below this value. The components of the output signal passed by the filter 11 are supplied to a differentiating circuit 12, which is so structured as to give unity gain at 15 kHz frequency. Below this value the differentiating circuit provides a gain which falls off at about 3dB per octave, as with the high-pass filter. Above this value, however, the gain rises at about 3dB per octave. Thus the combination of high-pass filter and differentiating circuit provides a more effective cut-off of frequencies below 15 kHz (i.e. 6dB per octave). The output of the differentiating circuit is fed to a comparator 13 which determines if the differentiated output is greater than a predetermined threshold value and generates a high-level output signal in such an event. The predetermined threshold value with which the

differentiator output is compared will in general be different for different denominations of coins to be tested and is selected to correspond with the coin denomination associated with inhibit terminal 18a. The comparator output signal is fed to a clock input of a monostable circuit 14 having a time constant τ_1. The output of the monostable circuit 14 is used, as explained below, for removing the inhibit at terminal 18a.

The induction coils 6 serve not only to validate coins on the basis of their electromagnetic properties but also to sense the presence of a coin within the measurement field of the coils. The validation circuit 7 generates an output signal PU which indicates the presence of such a coin within the measurement field. An example of the waveform of signal PU in the case of a coin which moves relatively quickly from the energy-absorbing element 3 through the measurement field to the acceptance gate 8 is shown as PU_1, and, in the case of a slow-moving coin, as PU_2, in Figure 3. It can be seen that the presence of a coin within the measurement field causes signal PU to adopt a high level. The coin presence signal is supplied via a signal expander 15, the purpose of which will be discussed below, and an inverter 16 to the input of the monostable circuit 14.

Neglecting the effect of the signal expander 15, this monostable circuit 14 thus receives at its input a high-level signal when there is no coin within the measurement field of the coils 6 and a low-level signal when a coin is present within the measurement field. In the event of comparator 13 generating a high-level output at a time when there is no coin present within the measurement field of coils 6, monostable circuit 14 generates a single square-wave output signal which is illustrated as MS_1 in the case of a fast-moving coin and MS_2 in the case of a slow-moving coin. It can be seen that these signals are identical, the monostable output signal MS being independent of the speed with which a coin travels from the impact surface 3 to the acceptance gate 8.

However, if a previously-inserted coin or slug is present in the measurement field at the time the comparator 13 produces its high-level output, the low level of the inverted PU signal will prevent the monostable from generating an output. Thus, the inhibit signal is not removed, and therefore inserting a counterfeit coin closely followed by a genuine coin will not result in erroneous acceptance of the counterfeit coin.

The pulse expander 15 serves to delay the falling edge of the coin presence signal pulse PU by the

maximum time taken by an acceptable coin to pass from the end of the measurement field and through the acceptance gate 8. This has the effect that no monostable output pulse can be generated until a previously inserted coin, having passed through the measurement field, has passed through the acceptance gate and the acceptance gate returned to its original position. The reason for this is to prevent a spurious electrical output which may be generated by the piezoelectric sensor in response to vibrations caused by the movement of the acceptance gate 8 from removing the inhibit applied to terminal 18a.

The output of the monostable circuit 14 is supplied to a first input terminal of a NOR gate 17, the output of which constitutes the inhibit signal I which is supplied to a selected inhibit terminal 18a of the validation circuit 7. It can be seen that, while the output of the monostable circuit 14 is at a high level, the inhibit signal I will be at a low-level so that its inhibiting effect is removed from terminal 18a for the duration of the monostable output pulse. The length τ_1 of the monostable output pulse is selected to be sufficiently great such that any acceptable coin will have entered the measurement field of coils 6 before the end of the pulse. The falling edge of the pulse generated by the monostable

circuit 14 is supplied to the input of an inverter 19 for converting this into a rising edge which serves to clock a latch circuit 20 so that the coin presence signal PU applied as an input to latch circuit 20 is caused to appear at the output of the latch circuit. This output is supplied to the second input of NOR gate 17, and it can be seen that, if at the time of the falling edge of the monostable output pulse the coin is present in the measurement field, the inhibit signal I continues to be held at its low level. The latch circuit 20 is supplied at its reset input with coin presence signal PU, delayed by time interval τ_2, such that, at a time τ_2 following the falling edge of coin presence signal PU, the latch circuit is caused to be reset and its output returned to a low level. At this point the inhibit signal I returns to its normal high level. This train of events is illustrated in the lowest part of Figure 3, where it can be seen that, in the case of a slow-moving coin, the inhibit signal I must remain at its low level for some time after the falling edge of the monostable circuit output pulse for an acceptable coin to be correctly validated.

It can thus be seen that, in the above-described embodiment, the high-level inhibit signal I is not removed from selected inhibit terminal 18a if an

inserted coin fails to meet the acceptability criteria of the impact-sensing circuitry 11, 12 and 13.

Furthermore, the inhibit signal I remains at its high level in the following circumstances:

(i) when an acceptable coin hits the energy-absorbing element at a time when there is already a coin within the measurement field of induction coils 6;

(ii) when an impact is detected at a time when the acceptance gate 8 may still be moving.

If desired, respective comparators 13 may be provided for determining whether the output of the piezoelectric sensor 4 is appropriate for coins of different denominations, and in response thereto for controlling the signals at respective inhibit terminals.

Various modifications to the embodiment described above can clearly be made without departing from the scope of the invention. For example, the high-level output signal from the comparator 13 could be used to cause a timer to count for a predetermined period which is equal to the shortest time taken for an acceptable coin to reach the point at which it is validated by coils 6, the inhibit being removed only after this period. If at the end of this period the coin presence signal PU indicates that no coin is

present within the measurement field of coils 6 the inhibit signal I may be caused to remain at its high level, since this situation would indicate a spurious impact sensor output signal. If a coin is indicated as being present, the inhibit signal is immediately caused to drop to its low level.

In addition, the sensor could be mounted in any position where it is capable of sensing the impact of the coin on the element 3. Furthermore, the entire circuitry could be incorporated into an integrated circuit chip in place of the provision thereof as the add-on circuit described above. In addition, although the validator of the specific embodiment incorporates a combination of electromagnetic sensing coils and piezoelectric sensor, the provision of the coils is optional. Although the coin entry is described above as having a portion curved within a plane perpendicular to the plane of a falling coin, it is also possible to provide a portion which curves within the plane of the coin; indeed any form of the curve may be provided, it being advantageous to prevent the path of the coin from entry to impact adopting a straight line.

Although in the preferred embodiment there is provided a high-pass filter stage followed by a differentiator stage, such an arrangement having been

found to produce good discrimination, it would be possible alternatively to use a single frequency-sensitive circuit stage the output of which is dependent on the gradient of at least part of the output signal from the impact sensor.

Furthermore, although in the preferred embodiment the validation of a coin causes removal of the inhibit on detection of the impact of an acceptable coin, it would be possible conversely to provide an inhibit signal only on detection of the impact of an unacceptable coin. This could be embodied by comparing the output of the impact sensor with a second, lower, threshold value to indicate a counterfeit coin. However, in this case the validator may be 'fooled' by a non-acceptable coin being gently lowered on to the impact surface thereby preventing generation of an output inhibit signal. Instead, therefore, there is preferably an independent sensor, such as an inductive or optical detector, located in the proximity of the position of impact. An inhibit signal would then be applied in the event of a coin being detected by the independent sensor when any output signal generated by the impact sensor fails to meet a coin acceptability criterion.

CLAIMS:

1. A coin validator comprising a coin entry, an impact surface positioned such that a coin having entered said entry will impact thereon, a sensor for detecting the impact of said coin on said surface so as to generate an output signal in response thereto and means capable of discriminating between impacts caused by genuine and counterfeit coins on the basis of whether or not the gradient of at least a part of said output signal meets a coin acceptability criterion.

2. A coin validator as claimed in claim 1, further comprising means connected to said discriminating means for generating an acceptability signal in response to the discrimination.

3. A coin validator as claimed in claim 2, further comprising means for sensing the presence of a coin within a region through which said coin is caused to pass in use after impacting said impact surface.

4. A coin validator as claimed in claim 3, further comprising means for inhibiting said acceptability signal in the event that a coin is

pr sent in the region when the output signal is generated.

5. A coin validator as claimed in claim 3 or claim 4, further comprising means for inhibiting said acceptability signal in the event of said output signal occurring within a predetermined interval of time following the departure of a coin from the region.

6. A coin validator as claimed in any one of claims 3 to 5, the acceptability signal generating means being arranged such that said acceptability signal is generated only if the coin passes through the region within a predetermined interval, preferably dependent on the detected speed of the coin, following said impact of said coin.

7. A coin validator as claimed in any one of claims 2 to 6, further comprising means for performing an additional measurement on a coin having entered said entry, wherein said acceptability signal generating means is adapted to generate said acceptability signal in response to said additional measurement in combination with said discrimination.

8. A coin validator as claimed in claim 7, further comprising means for generating a signal indicative of the denomination of said coin on the basis of said additional measurement.

9. A coin validator as claimed in any one of claims 1 to 8, wherein said coin acceptability criterion is specific to coins of a single denomination.

10. A coin validator as claimed in any one of claims 1 to 9, wherein said discriminating means is adapted for comparing said gradient with a predetermined value.

11. A coin validator as claimed in any one of claims 1 to 10, wherein said discriminating means comprises means for differentiating said at least a part of said output signal and means for detecting whether the resultant differentiated signal meets a predetermined criterion.

12. A coin validator as claimed in any one of claims 1 to 11, wherein said discriminating means comprises a high-pass filter.

13. A coin validator as claimed in claim 12, when appendant to claim 11, wherein said high-pass filter is connected between the output of said sensor and said differentiating means, said at least a part of said output signal comprising that part passed by said high-pass filter.

14. A coin validator as claimed in any one of claims 1 to 13, wherein said entry is configured so that a coin cannot travel in a straight line from a point of insertion to the impact surface.

15. A coin validator as claimed in any one of claims 1 to 14, wherein said impact surface and said sensor are both carried by an integrally formed structure of the validator.

16. A coin validator as claimed in any one of claims 1 to 15, wherein said sensor is a piezoelectric sensor.

17. A coin validator as claimed in claim 16, wherein said piezoelectric sensor is formed from a ceramic material.

18. A method of validating coins comprising

sensing the impact of a coin hitting an impact surface, generating an output signal in response thereto and discriminating between impacts caused by genuine and counterfeit coins on the basis of whether or not the gradient of at least a part of said output signal meets a coin acceptability criterion.

19. A method as claimed in claim 18, further comprising the step of performing a measurement on said coin and generating a signal indicating whether the coin is acceptable in response to said measurement in combination with the result of said discrimination.

20. A method as claimed in claim 19, including the step of providing a first acceptability signal indicative of an acceptable coin of a first denomination in response to both the measurement and the result of the discrimination, and a second acceptability signal indicative of an acceptable coin of a second denomination in response to said measurement and regardless of any output signal caused by impact with said impact surface.

21. A coin validator substantially as described herein with reference to the accompanying drawings.

22. A method f validating coins substantially as described herein with reference to the accompanying drawings.

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